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Small UAS Analysis of Laser Designation and Search and Target Acquisition Capabilities in an Urban Environment

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Bottom Line

Customer: TRAC

- Completed for TRAC in September 2007 as a follow-on to TRAC UAS Mix Analysis of 2006
- Analysis Goals
  - Small UAS Laser Designation targets in urban environment
  - Rotary Wing (RW) versus Fixed Wing (FW) UAS detection
- Implementation
  - FOCUS was used for all modeling and analysis
  - Two missions: laser designation and persistent surveillance
  - Three flight modes: FW, RW, P&S
- Results
  - Poor LD of moving targets in high density terrain
  - Inconsistent LD of moving targets in medium density terrain
  - Good LD of stationary targets
  - Perch-and-Stare could be the best choice for persistent surveillance
  - Surveillance of an intersection by hovering gives better performance than a circular flight path around the area

Fusion Oriented C4ISR Utility Simulation
FOCUS

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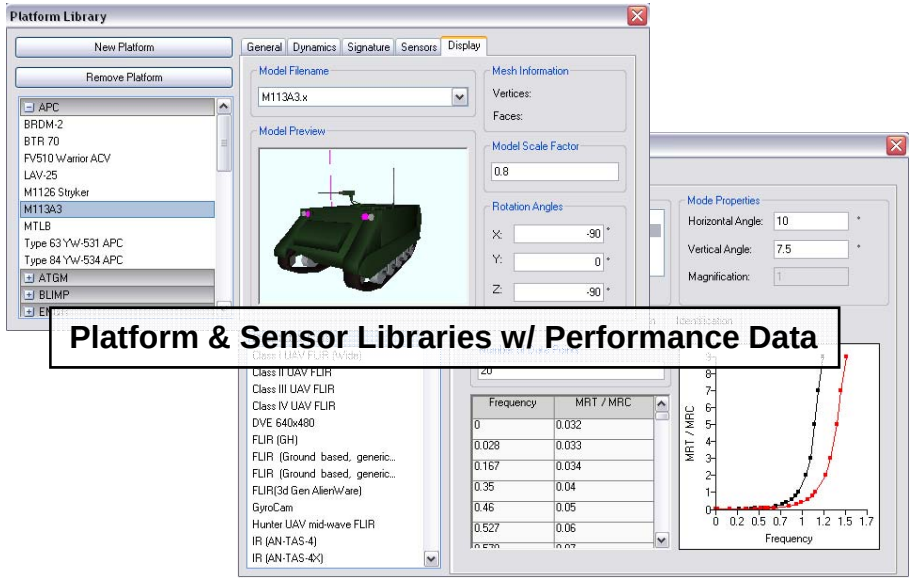
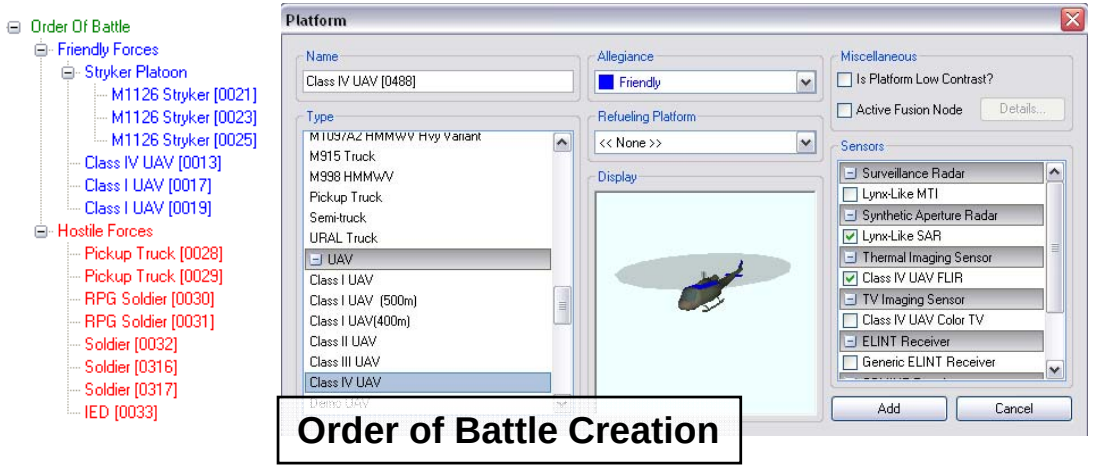


Platform & Sensor Libraries w/ Performance Data

High Resolution Terrain – 3D Battle Space

FOCUS solves these problems

- Modeling of C4ISR functions using flexible architecture
- Explicit modeling of fusion processes
- Fast turn-around time-- Graphical mission tools and integrated analysis package
- System of systems analysis



Order of Battle Creation

FOCUS Lens
FUSION ORIENTED C4ISR UTILITY SIMULATION

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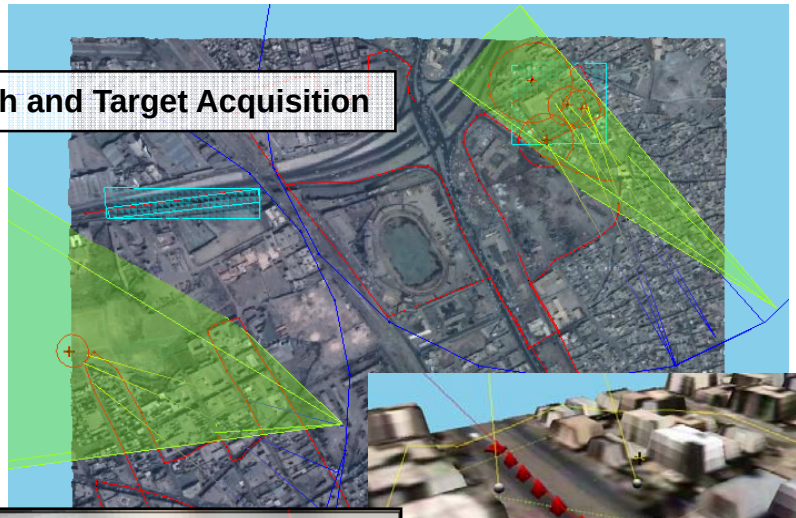
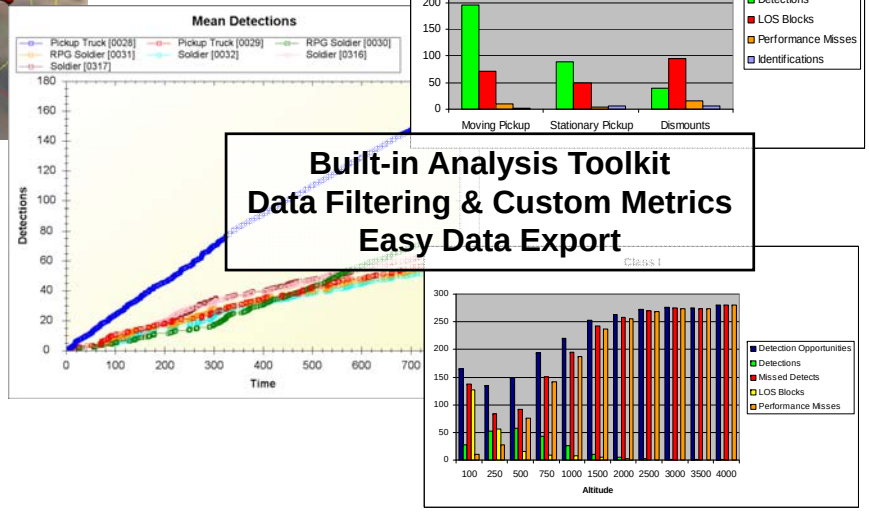
Fusion Oriented C4ISR Utility Simulation
FOCUS



Potential Applications

- –C4ISR analysis
  - •Sensor mix questions
  - •C4ISR in urban terrain
  - •Collection / search strategy evaluation
  - •Fusion effects
  - •Unit behavior effectiveness
  - •Sensor Cueing / collaborative C4ISR
- –TTP Development and Analysis



Built-in Analysis Toolkit
Data Filtering & Custom Metrics
Easy Data Export

Other Projects

- UAS Mix Pilot Study
- Sensor Fusion Analysis
- Fusion Algorithm Test Bed

FOCUS Lens
FUSION ORIENTED C4ISR UTILITY SIMULATION

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Caveats/Limitations/Assumptions

- **Limited Scenarios**
- **UAS Movement**
  - **No jitter**
  - **Fixed-Wing UAS**
    - **Minimum turn radius used for path; circular flight path around intersection**
  - **Hovering UAS**
    - **Stays behind target when tracking; standoff when lasing**
    - **Hovers at a point with LOS to intersection for 5 minutes then moves**
  - **Perch-and-Stare**
    - **Edge of building, 10 m from intersection**
    - **Altitudes: 20 m (High Density), 10 m (Medium Density)**
- **C4ISR**
  - **Communications simplified**
- **Sensors**
  - **3-axis mount, 2 FOVs**
- **Warhead receiver**
  - **Low fidelity representation**
  - **Horizontal safe angle**
  - **Assumed LOS**
  - **Power on Receiver measured by NVLaserD Model at each time step**

Terrain Types

High Density

- **Samarra, Iraq**
- **Tall buildings (3-5 story), tightly packed**
- **Narrow streets with some intersecting wide avenues**

Medium Density

- **Fallujah, Iraq**
- **Low residential buildings (1-2 story)**
- **Narrow streets and back alleys**
- **Enclosed courtyards**

Run Matrix

UAS Follow-On Study Run Matrix			
Laser Designation Scenario			
Run #	**Target Type**	**Terrain**	**Flight Characteristic**
1	Moving	High Density	Fixed-Wing
2	Moving	High Density	Rotary-Wing
3	Moving	Medium Density	Fixed-Wing
4	Moving	Medium Density	Rotary-Wing
5	Stationary	High Density	Fixed-Wing
6	Stationary	High Density	Rotary-Wing
7	Stationary	Medium Density	Fixed-Wing
8	Stationary	Medium Density	Rotary-Wing
Intersection Surveillance Scenario			
Run #	**Sensor Type**	**Terrain**	**Flight Characteristic**
9	IR	High Density	Fixed-Wing
10	IR	High Density	Rotary-Wing
11	IR	High Density	Perch-and-Stare
12	IR	High Density	Perch-and-Stare Wide FOV
13	IR	Medium Density	Fixed-Wing
14	IR	Medium Density	Rotary-Wing
15	IR	Medium Density	Perch-and-Stare
16	IR	Medium Density	Perch-and-Stare Wide FOV
17	TV	High Density	Fixed-Wing
18	TV	High Density	Rotary-Wing
19	TV	Medium Density	Fixed-Wing
20	TV	Medium Density	Rotary-Wing
Sensitivity Analysis			
	Altitudes	100,200,300,400,500	
	Standoff Ranges	100,200,400,500,700	
Run #	**Scenario**	**Terrain**	**Flight Characteristic**
21	LD Moving	High Density	Fixed-Wing
22	LD Moving	High Density	Rotary-Wing
23	Surveillance	High Density	Fixed-Wing
24	Surveillance	High Density	Rotary-Wing

Fixed Wing

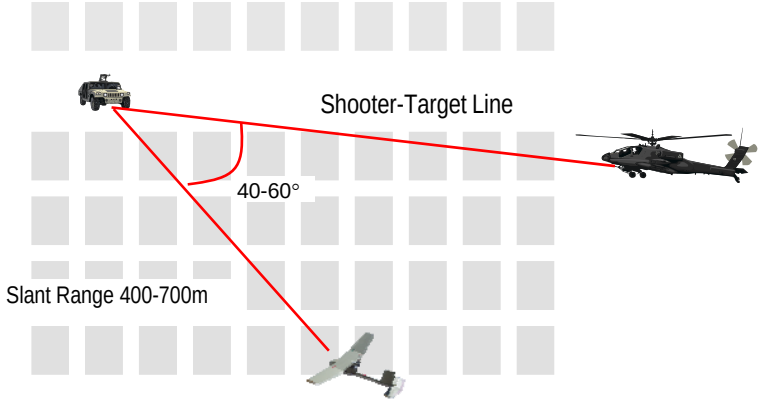
Rotary Wing

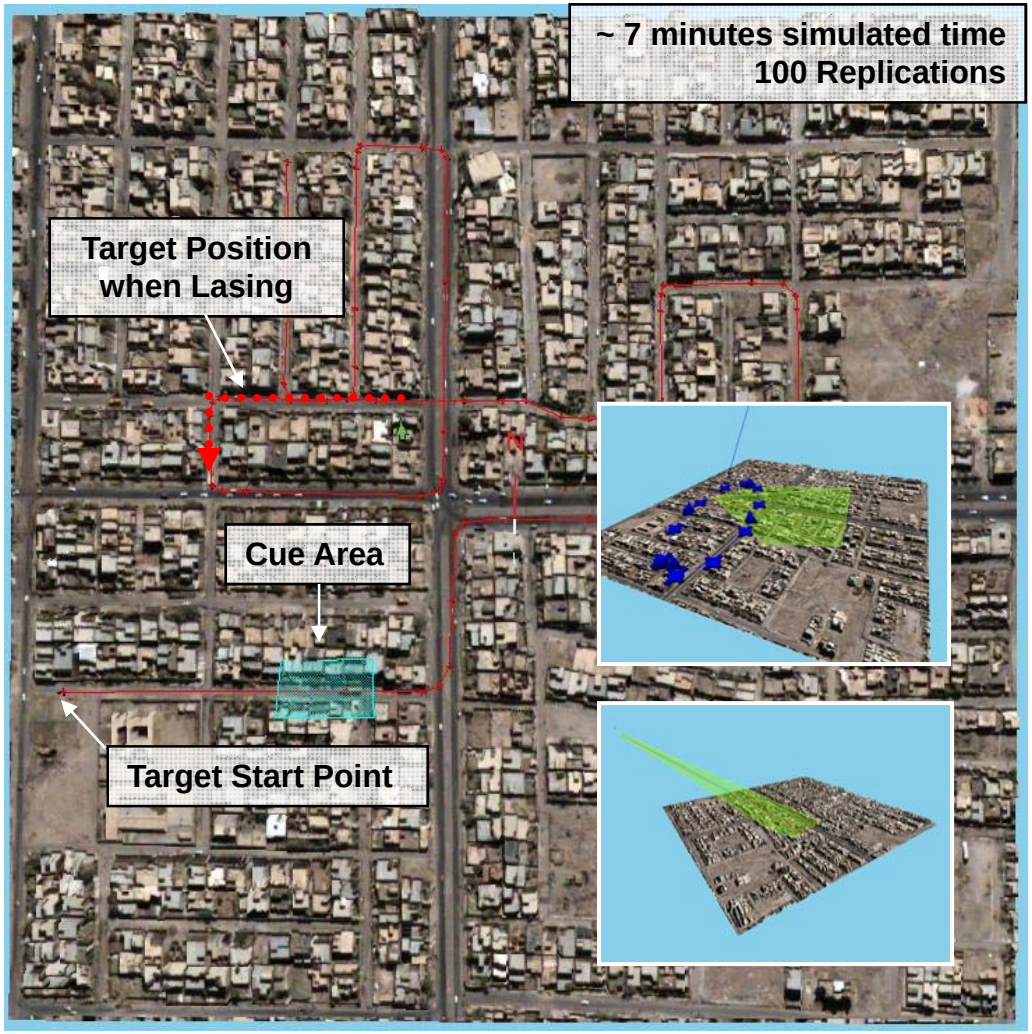
Perch/Stare

Perch/Stare Wide FOV

Laser Designation Scenario

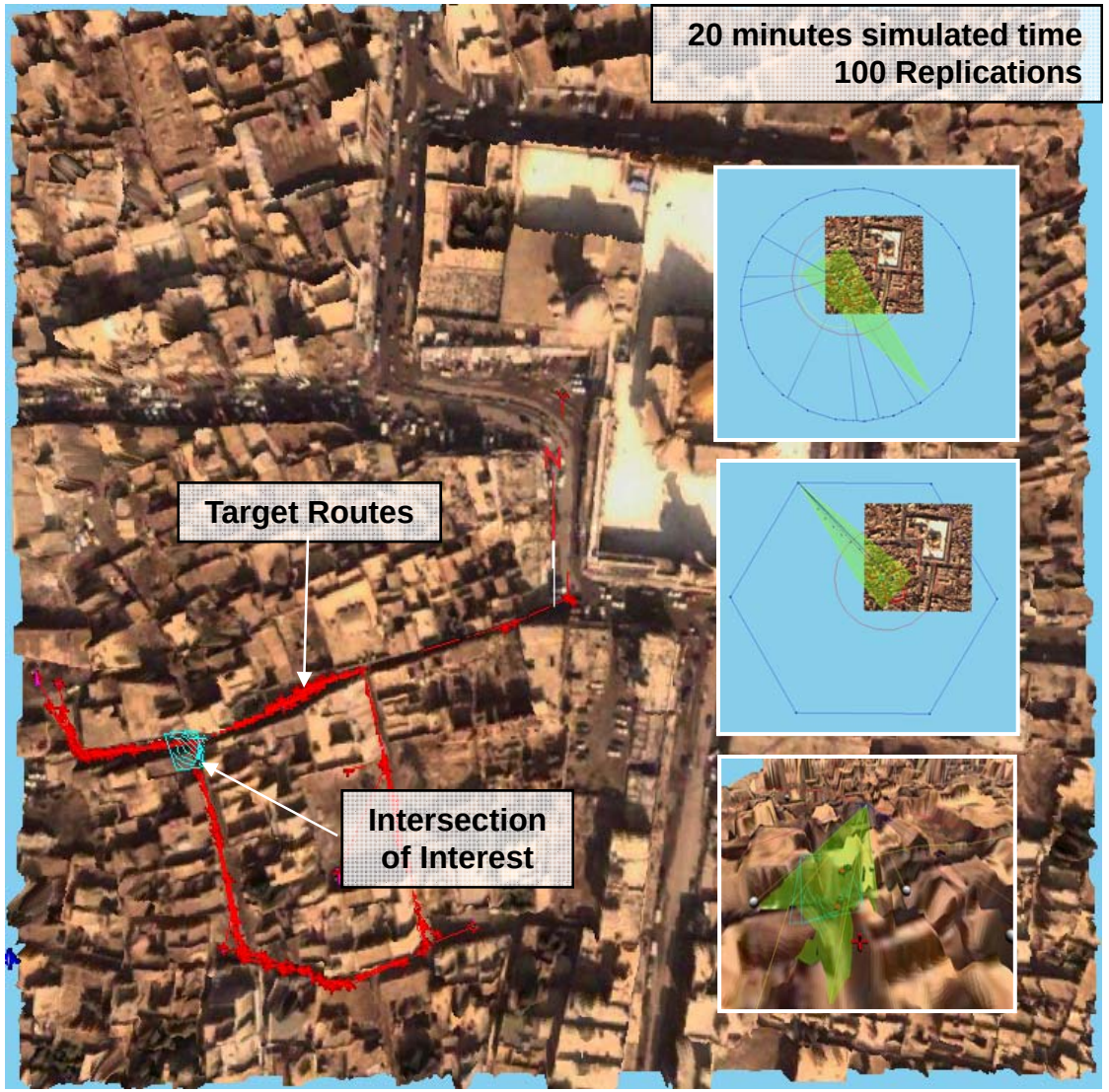
- Moving or Stationary Target
- After tracking target for 5 minutes, UAS moves into slant range while maintaining "safe angle"
- Warhead/Receiver moves toward target
- Once warhead reaches target, simulation ends





Intersection Surveillance Scenario

- 20 minute coverage w/ FLIR or TV
- Targets circle around block
- Sensor only attempts detection at intersection
- FW UAS – circular flight path
- RW UAS – hovers at points on circle for 5 minutes
- Perch-and-Stare UAS – Fixed position at edge of building

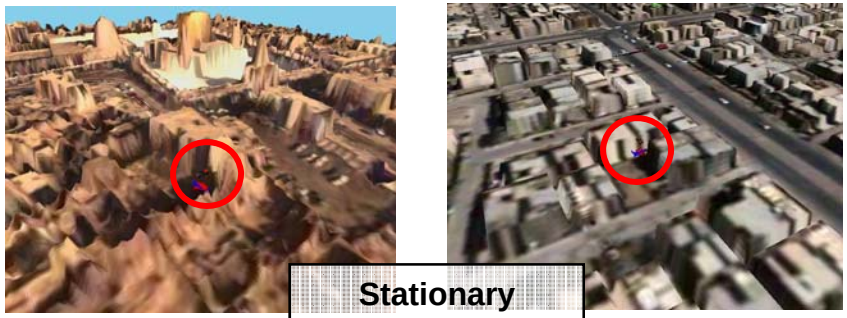


UAS Follow-On Results

Issue 1: Can a Small UAS laser designate targets in an urban environment?

- **Moving Target**
  - **High Density – LOS blocks result in unacceptable Lock-On times**
  - **Medium Density - Target maneuvering results in inconsistent Lock-On**
- **Stationary Target**
  - **Lock-On near 100% of overall lasing time for all scenarios**

Moving Target Positions during Lasing

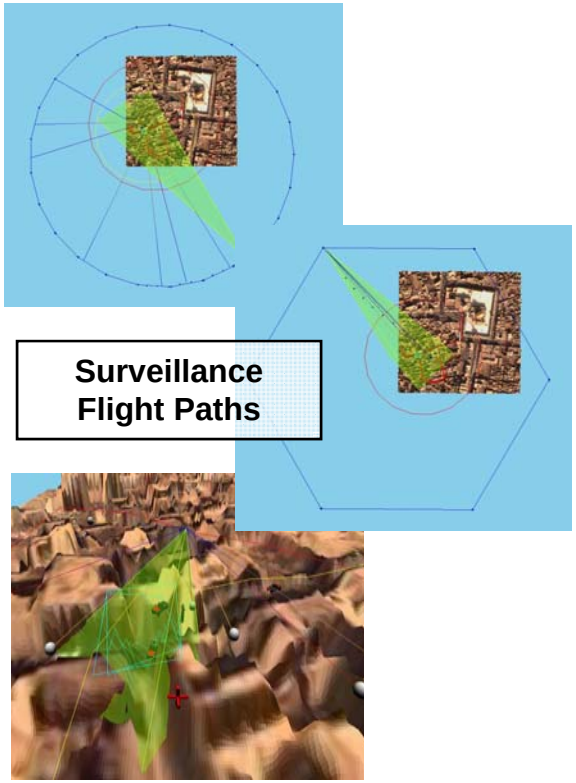


Stationary Target Positions

UAS Follow-On Results

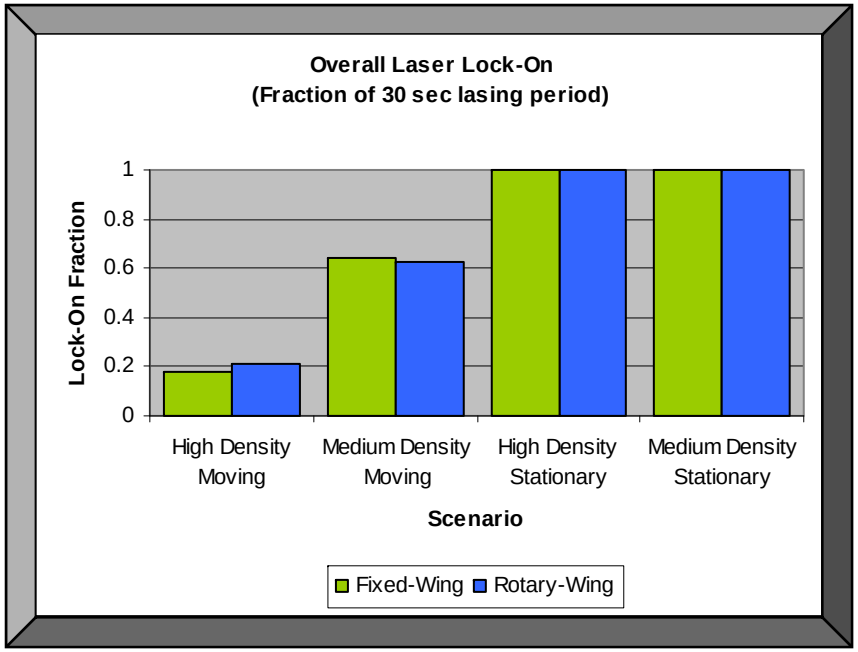
Issue 2: Does a Fixed-Wing UAS provide better acquisition performance than a Rotary-Wing UAS?

- **Laser Designation**
  - Similar results for both FW and RW cases
  - LOS blocks caused by constrained movement
- **Surveillance**
  - High Density – hovering can increase acquisition performance
  - Medium Density – FW and RW UAS perform equally well
  - Perch-and-Stare Operations, when given an appropriate sensor, increases performance in High Density Environments



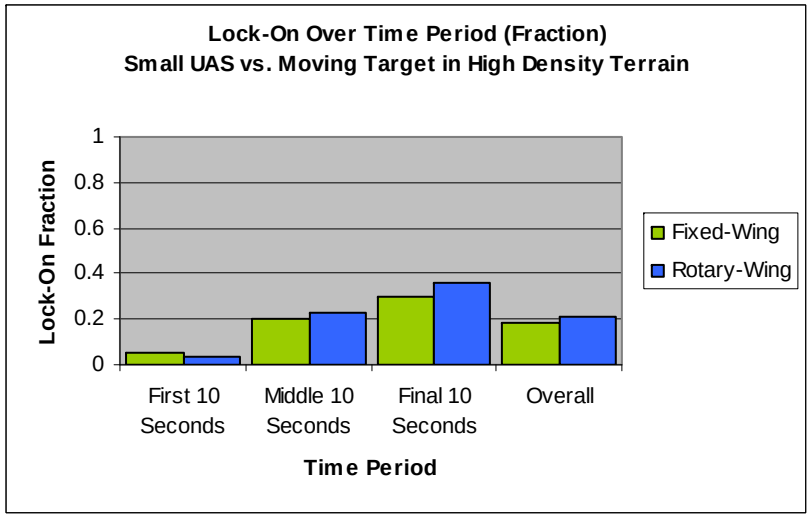
Laser Designation Results

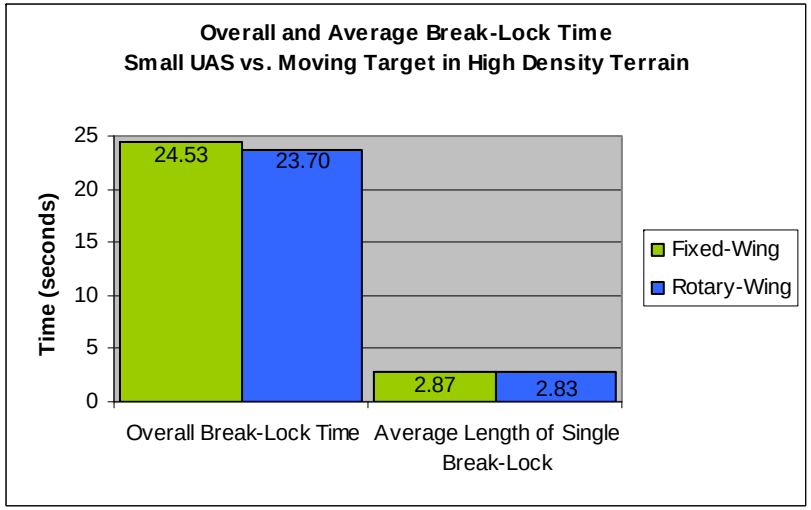
Overall Lock-On Results



- **Similar performance for FW and RW UAS**
- **Moving Target – laser rarely keeps a continuous lock on the target due to LOS blocks**

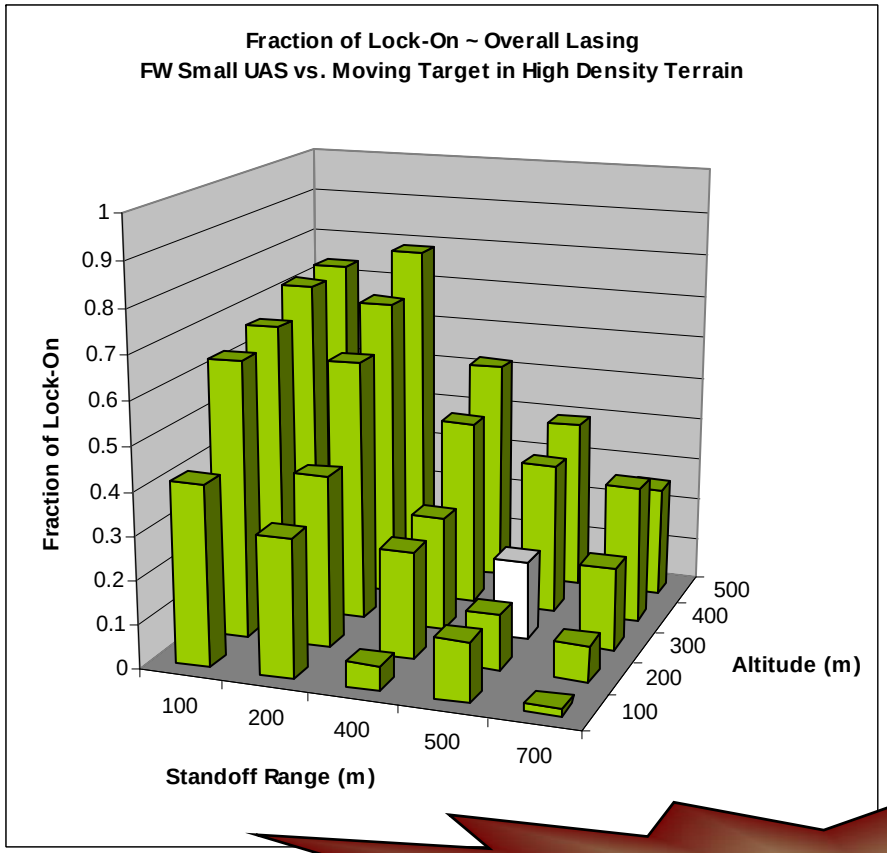
Moving Target / High Density Terrain In Depth Results

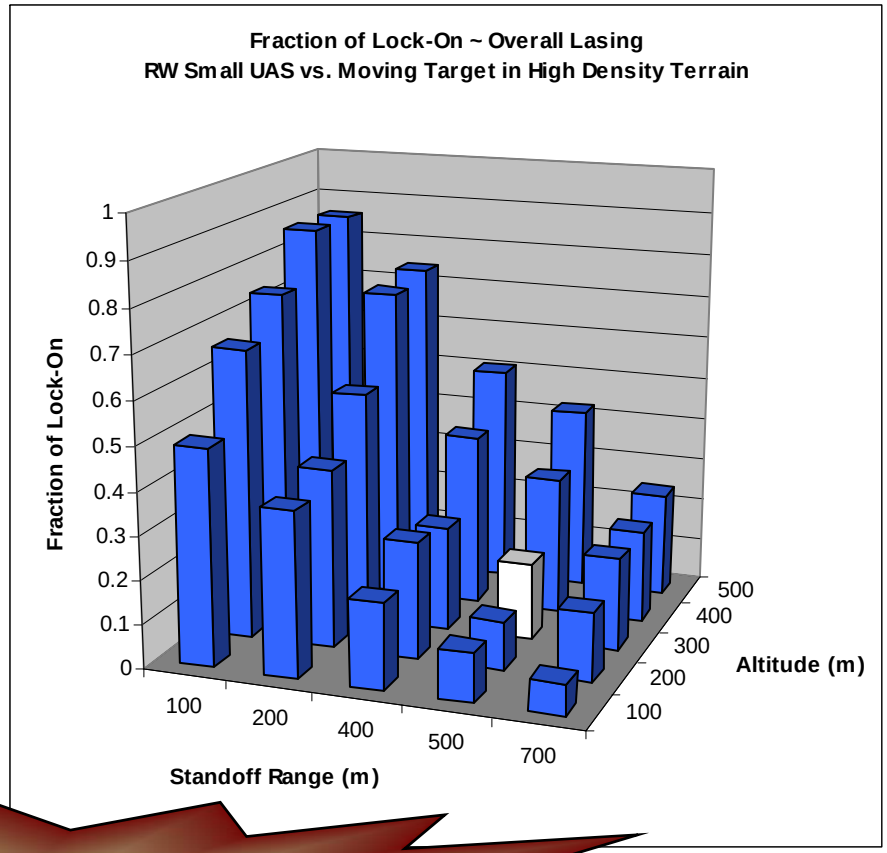




FOCUS Lens
Fusion Oriented C4ISR Utility Simulation

Laser Designation Results
Sensitivity Analysis





The probability of Lock-On success increases with an increase in altitude and/or decrease in ground standoff range

☐ **Operational Parameters**

FOCUS Lens2
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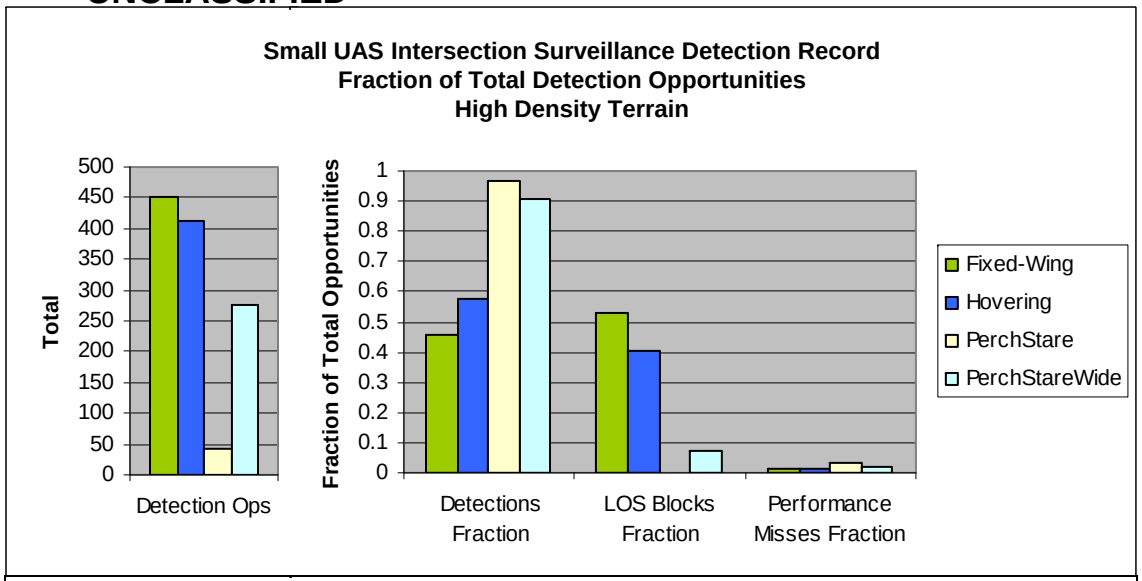
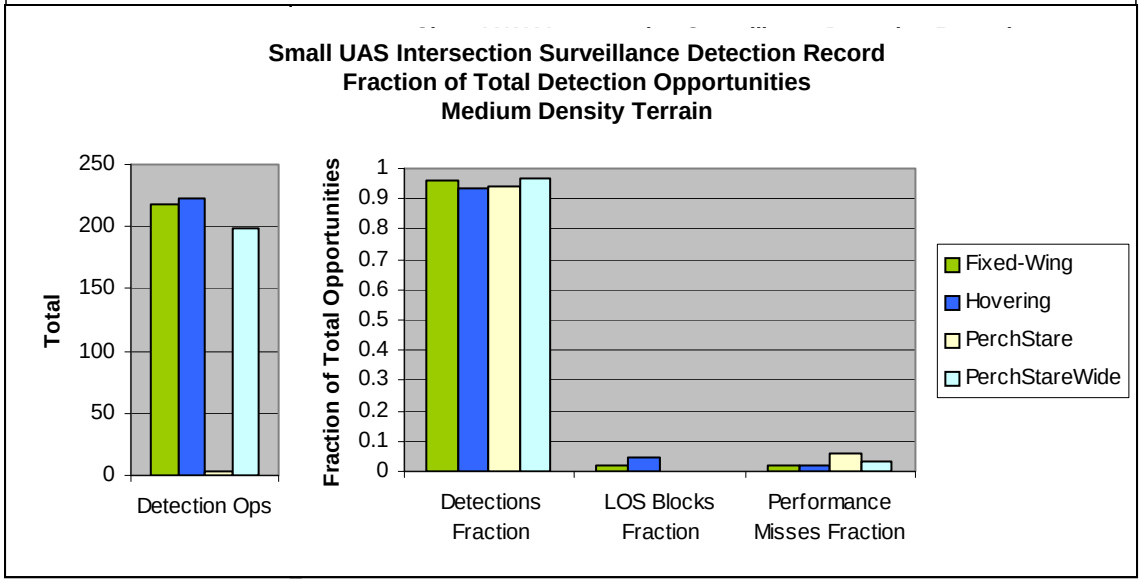
Intersection Surveillance Results
IR Sensor

- **High Density Terrain**
  - **Hovering UAS performance exceeds Fixed Wing**
  - **Determining Factor: LOS**
  - **Perch-and-Stare given wider FOV outperforms flights at operational altitude**
- **Medium Density Terrain**
  - **Hovering and Fixed-Wing UAS perform equally well**
- **Perch-and-Stare**
  - **Poorly performs due to the size of the FOV (low Ops)**
  - **Footprint shrinks as UAS is closer to ground level**
- **TV Sensor gives similar results to IR Sensor**



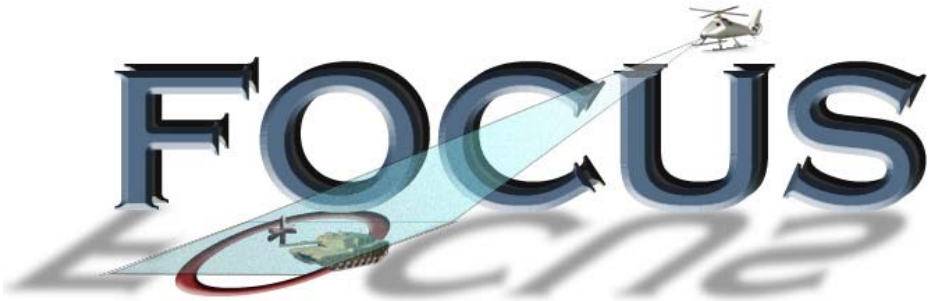


Summary

Analysis Results provided to TRAC Sept '07

- **Conclusions**
  - **Small UAS has extreme difficulty lasing moving targets in high density urban environments**
  - **Lasing moving targets in medium density terrain is possible but not certain**
  - **Lasing of stationary targets is not an issue given LOS**
  - **Perch-and-Stare may be the best choice for surveillance of a point or intersection**
  - **Surveillance of an intersection by hovering gives better performance than a circular flight path around the area**
- **Next Steps**
  - **TRAC used this data in conjunction with Soldier interviews on the operational ability/benefits of the FW and RW Small UAS when compiling the final report**
  - **AMSAA will be conducting an additional UAS Mix Analysis using improved methodology for FOCUS**

Questions/Comments?



FUSION ORIENTED C⁴ISR UTILITY SIMULATION

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ARMY MATERIEL SYSTEMS ANALYSIS ACTIVITY

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